IN THE UNITED STATES BANKRUPTCY COURT

FOR THE DISTRICT OF DELAWARE

In re:	)	Chapter 11
	)	
W. R. GRACE & CO., et al.,	)	Case No. 01-01139 (JKF)
	)	(Jointly Administered)
Debtors.	)	
		Objection Deadline: July 6, 2007 at 4:00 p.m. **Hearing Date: July 23, 2007 at 2:00 p.m.** **Related to Docket No. 13406 and 15156**

DEBTORS' MOTION FOR LEAVE TO FILE EXPERT REPORT OF DR. ELIZABETH ANDERSON IN CONNECTION WITH THE LACK OF HAZARD HEARING RELATING TO ASBESTOS PROPERTY DAMAGE CLAIMS

Debtors submit the following motion requesting leave from the Court to file the expert report of Dr. Elizabeth Anderson in connection with the lack of hazard hearing relating to asbestos property damage claims, and, in support thereof, state as follows:

Procedural History

1. On October 13, 2006, the Court entered the Amended Order Setting Various Deadlines Regarding Objections to Asbestos Property Damage Claims (Docket No. 13406) (the "CMO") that set a litigation schedule for the more than 650 then-pending asbestos property damage claims.

2. Pursuant to the CMO, certain objections to property damage claims, including product identification and limitations periods, were scheduled to be adjudicated on April 23, 24 and 25, 2007. The CMO provided for the filing of expert reports before the hearing. In addition, summary judgment motions were to be filed on or before February 16, 2007.

3. Pursuant to the CMO, to the extent any of the asbestos property damage claims survive Debtors' product identification and limitation periods objections, the hearing to adjudicate Debtors' lack of hazard objections to those remaining claims was originally scheduled to take place on May 30 and 31, 2007. With respect to that hearing, the CMO provided for simultaneous filing of all parties' expert reports relating to the lack of hazard objections on or before January 15, 2007 and the simultaneous filing of all parties' rebuttal reports about four weeks later, on or before February 9, 2007. The parties submitted their expert witness designations/reports on the lack of hazard issues on or about January 15, 2007 and their rebuttal expert reports on or about February 9, 2007.

4. On February 16, 2007, Debtors filed several motions for summary judgment on more than 300 then pending property damage claims on the basis, *inter alia*, of the expiration of applicable limitations periods. The Court heard arguments on Debtors' summary judgment motions on April 9, 2007. Immediately following oral argument, the Court conducted a conference to discuss a pretrial schedule for the April 23 – 25, 2007 hearing.

5. In light of the pending summary judgment motions and by stipulation of the parties and order of Court, the April 23-25, 2007 trial scheduled by the CMO was limited to Debtors' product identification objections to certain pending asbestos property damage claims. The Court's April 11, 2007 Modified Amended Scheduling Order for Adjudication of Asbestos PD Claims [Docket No. 15156] set forth the pre-trial schedule.

6. Similarly, by stipulation of the parties and the Court's April 11, 2007 Order, the CMO dates applicable to the hearing for the limitations period objections were suspended to allow the Court ample time to consider Debtors' motions for summary judgment

and to adjudicate Debtors' product identification objections to certain asbestos property damage claims at the April 23-25, 2007 hearing. At the April 19, 2007 pre-trial conference for the April 23-25 hearing, the dates and deadlines applicable to the hearing for the lack of hazard objections were also suspended pending further scheduling by the Court.

7. With respect to limitation period objections, the Debtors have proposed that those objections for certain of the asbestos property damage claims be adjudicated on June 26, 2007 and on July 30 –August 1, 2007. The limitations period objections to the remaining claims, including any claims that survive the pending motions for summary judgment, have not yet been scheduled, but will be scheduled at a later date, by the Court. In addition, the Court has not yet scheduled or heard argument on the limitation period objections to the Canadian asbestos property damage claims.

8. In light of the foregoing, there is no date currently scheduled for the adjudication of the lack of hazard objections relating to any asbestos property damage claims that remain after the adjudication of Debtors' product identification and limitation period objections. The adjudication of the Debtors' product identification and limitations period objections will not be completed until sometime after August 2007 at the earliest.

Dr. Elizabeth Anderson Expert Report

9. By this Motion, Debtors respectfully seek leave to file the Expert Report of Dr. Elizabeth Anderson (the "Anderson Report") that is attached hereto as Exhibit A in connection with the lack of hazard hearing.

10. Dr. Anderson, who submitted a risk assessment expert report in the ZAI proceedings, is a former Director of EPA's Risk Assessment Programs and past President of the

Society of Risk Analysis. As Director of the office of Health and Environmental Assessment at EPA, Dr. Anderson helped create EPA's risk assessment process.

11. As the Court is aware from the ZAI Science Trial proceeding, a risk assessment is an important and valuable tool that will aid the Court in determining whether Debtors' in-place asbestos-containing materials present a hazard to building occupants.

Debtors' Prior Notification to Court and the Asbestos PD Claimants

12. Debtors have previously informed both the Court and the asbestos property damage claimants that they contemplated filing an expert report on risk assessment in connection with the lack of hazard hearing. See Transcripts of Hearing of January 23, 2007 (Docket No. 14465) (the relevant pages of which are attached hereto as Exhibit B), March 8, 2007 (the relevant pages of which are attached hereto as Exhibit C) and May 21, 2007 (Docket No. 15948).

13. This issue was first raised by Debtors' counsel prior to, and then discussed at, the January 23, 2007 Omnibus Hearing:

> MR. RESTIVO: . . . Secondly, Your Honor, with respect to the May 30-31 no hazard hearing, expert reports were to be submitted by January 15. We have agreed with counsel for the claimants that we do not object to any late designations of Dr. Frank or Dr. Brody. . . Fourth, Your Honor, we may want to file an expert report after January 15. We've asked the claimants to agree that we can do that, and we would agree to give them the same 24 days to respond. I'd like to address that at the end of my report.
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> MR. RESTIVO: . . . Lastly, Your Honor, coming back, we are giving consideration, and again, I've indicated this to Mr. Dies and to Mr. Baena, but same issue. They can't bind all the claimants. We are giving consideration to submitting a risk assessment report for the no hazard hearing set for May 30, 31. We have missed the

> January 15 deadline. We did not file a risk assessment report. We have asked them and now we're asking the Court for permission to file a risk assessment report if we so elect to do so out of time with the understanding that the claimants would have the same 24 days to respond to it that they would have if we filed it on January 15, and we're going to make a decision whether to do such a report in the next few days, but if we are going to do such a report, we have to retain an expert. It has to be written, and so we're not going to be able to file it for a little bit of time, and we would like the opportunity to file it out of time, giving the other side 24 days to respond and again, while I have raised this with a couple of the attorneys, since they can't bind everyone, I'm now raising it with the Court to see if there's any opposition to that and see where we are.
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> * * *
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> MR. SPEIGHTS: . . . On the risk assessment issue, I would – you know, my philosophy is that you work with opposing counsel on these issues, and Mr. Restivo has generously agreed that I can list [Dr. Frank], and I appreciate that, and I'm sure I'll work with Mr. Restivo about the risk assessment person. It may be when I talk to him I might say, well, now, if you're introducing a risk assessment person, we might want, I doubt it, a risk assessment person too, but I believe I can and I believe that other PD claimants can work with Mr. Restivo to narrow the disputes.
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> * * *
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> MR. DIES: . . . On the issue of adding the risk assessment, for the record, I told Mr. Restivo I'm inclined to agree to that, subject to working that out. I just wanted to say that.

<u>See</u> Transcript of January 23, 2007 Hearing, Exhibit B hereto, at 94 - 95, 101 – 103, 108 and 112.

14. This issue was raised again at the March 8, 2007 asbestos property damage claims status conference:

> MR. RESTIVO: . . . Another item, Your Honor, it does not relate to the April 23 hearing, rather, it relates to the no hazard hearing on May 30, 31. I believe I mentioned this in open Court. I have talked to a couple of claimants' attorneys about it, again, run into the same issue that no one can speak, and so, I want to raise it now so they also tell Mr. Baena their position, and that is we are

> considering filing out of time a risk assessment expert report with respect to the May 30, 31 hearing. We have proposed to anyone we've talked to that they not object to us filing out of time, and we would give them the same 24, 25, 26 days they would have had to respond if we had filed on time. I don't know that we've heard any objections to that, but we have heard that no one can agree on behalf of everyone to that, and so, I would like claimants to also tell Mr. Baena their position on that issue.
>
> THE COURT: Okay. Well, Mr. Restivo, that's fine and I will ask claimants to please tell Mr. Baena their position on that issue also by the close of business on Monday, March 12th, and Mr. Baena to report back to the debtor on that issue as well. But if they are going to object, they are, so file your report, and if they object, you know, we'll just have a hearing and do it the way we normally do things. That's all I can tell you. But nonetheless, if the debtor is going to file a report and give the other side the appropriate amount of time also to file a report, then that may be something that you would prefer to have happen, all of you. So, why don't you consider it, tell Mr. Baena your position, and see if that's one that you can't work out amicably.

See Transcript of March 8, 2007 Hearing, Exhibit C hereto, at 46 - 47.

15. Debtors' counsel has not been advised of any specific objection to the above notification of Debtors' intention of filing a risk assessment expert report.

16. Since that time, in addition to preparing and arguing summary judgment motions, engaging in settlement discussions, adjudicating their product identification objections and addressing numerous issues raised by the property damage claimants, which efforts have resulted in reducing the number of pending claims from over 650 to approximately 215,[1] Debtors have worked with Dr. Anderson to submit the attached expert report on risk assessment for the lack of hazard hearing.

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[1] The approximately 215 remaining active claims do not include the claims that are subject to written or oral settlement agreements.

17. Granting Debtors the relief requested will not prejudice the asbestos property damage claimants. The hearing on Debtors' lack of hazard objections has not yet been scheduled by the Court and will not be scheduled until the adjudication of all of Debtors' product identification and limitation periods objections is complete. Moreover, the asbestos property damage claimants will have at least the four weeks originally provided in the CMO to submit a rebuttal report and will have the opportunity to depose Dr. Anderson regarding the opinions set forth in her report.

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WHEREFORE, for the foregoing reasons, Debtors request that the Court enter the attached Order granting them leave to file the Expert Report of Dr. Elizabeth Anderson.

Dated: June 12, 2007

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EXHIBIT A

Exponent®

An Evaluation of the Exposure and Risk Associated with In-Place Asbestos in Buildings

Report by
Elizabeth L. Anderson, Ph.D., A.T.S. Fellow

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Exponent®

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A.T.S. Fellow

June 8, 2007

Elizabeth L. Anderson Date

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Acronyms and Abbreviations

ACM	asbestos-containing materials
BMI	body mass index
CAG	Carcinogen Assessment Group
EPA	U.S. Environmental Protection Agency
IRIS	Integrated Risk Information System
MCL	maximum contaminant level
NCP	National Contingency Plan
NRC	National Research Council
O&M	operations and maintenance
OHEA	Office of Health and Environmental Assessment
OSHA	Occupational Safety and Health Administration
PCM	phase contrast microscopy
PCME	PCM-equivalent
PEL	permissible exposure limit
SIR	standardized incidence ratio
SSSD	small-scale, short-duration
TEM	transmission electron microscopy
TWF	time-weighting factor

1 Qualifications

1. I am a Principal Scientist and Group Vice President for Health Sciences at Exponent, a science and engineering consulting firm.

2. I have a Ph.D. in organic chemistry and am a Fellow of the Academy of Toxicological Sciences. I worked for 14 years at the U.S. Environmental Protection Agency (EPA), from October 1971 to December 1985, where I directed EPA's central risk assessment programs for the last 10 years of my tenure. Specifically, in 1975, I became the Executive Director of an intra-Agency committee that was commissioned to write an Agency cancer policy. This committee developed the Agency's first guidelines for assessing risk associated with exposure to suspected carcinogens in the environment. Subsequently, in 1976, I established EPA's first Carcinogen Assessment Group (CAG), which formed the core for the enlarged office, the Office of Health and Environmental Assessment (OHEA), now called the National Center for Environmental Assessment, which was established in 1978. As the director of the first CAG and then OHEA, I had responsibility for the central risk assessment activities of EPA for 10 years before I left the Agency. The primary functions of this office were to conduct assessments and estimate the toxicity of a wide variety of toxic agents, provide leadership to establish EPA-wide guidelines for toxicity and risk assessments, and oversee EPA's health assessment programs. During this time, I coauthored hundreds of assessment documents. Of particular relevance to the issues in this lawsuit, my office was responsible for the assessment of toxic pollutants under the Clean Air Act and provided health assessments on the scientific basis for establishing health advisories and maximum contaminant levels (MCLs) under the Clean Water Act. During my tenure, my office was responsible for performing the first risk assessments for asbestos in air and water. In particular, this work included the 1986 risk assessment for asbestos, which formed the basis for the current EPA IRIS file and the asbestos potency factor.

3. Since leaving EPA, I have continued to participate actively in the sciences of health and environmental risk assessment. For example, I am Past President of the Society for Risk Analysis, and am currently Editor-in-Chief of the journal, *Risk Analysis: An International Journal*, which is the leading peer-reviewed international journal on topics of risk assessment. I regularly serve on expert peer-review and advisory committees on risk assessment topics for EPA and other organizations, including a recent appointment to the U.S. Department of Energy's Los Alamos National Laboratory Expert Advisory Committee and recent service on an expert committee for the National Academy of Sciences. My *curriculum vitae*, including a list of my publications for the last 10 years, is provided in Appendix A. A list of recent depositions and trial testimony is provided in Appendix B. My compensation rate is provided in Appendix C.

4. I am submitting this report at the request of W.R. Grace and Co. ("Grace"). My conclusions are based on information available to me on the date of this report and are expressed to the best of my knowledge with a high degree of scientific certainty. This report may be supplemented or revised if new information, analysis, reports or data become available.

2 Conclusions

I have reviewed the available scientific data and studies related to asbestos exposures and risks associated with in-place asbestos-containing materials (ACM) in buildings. From this information, I have conducted a risk assessment to estimate the potential risks associated with ACM for maintenance workers and building occupants. From this review and analysis, I have reached the conclusions presented below.

Conclusion 1: Health risk assessment is the scientifically appropriate and accepted methodology for assessing the potential cancer risk associated with ACM.

Risk assessment is the scientifically accepted process for assessing whether exposure to an environmental substance has a significant potential to cause adverse health effects. Risk assessment is routinely applied by federal, state, and local U.S. governmental organizations and international organizations, and is well accepted in the scientific community. Risk assessors evaluate the available human epidemiology and animal toxicology studies to evaluate the hazard and quantify the dose-response of a substance. The estimated exposure of an individual takes into account the concentration, frequency, and duration of exposures to a particular substance. The resulting exposure assessment for carcinogens includes a time-weighted average for a lifetime exposure and is compared with health-effects data relating to the potential effects associated with a given exposure. From this comparison, the risk of adverse health effects is estimated. Risk assessment is a generally conservative process that is designed to err on the side of overestimating risk when confronted with uncertainty.

Conclusion 2: The available exposure data for building maintenance workers from ACM disturbance activities were reviewed. The vast majority of exposures were in compliance with the current OSHA PEL, the operative occupational regulatory standard for workers. Also, a risk assessment was conducted according to accepted EPA methodologies. These calculations show that the lifetime risks for maintenance workers are well below the risk level associated with the OSHA PEL, the standard set by OSHA to protect worker health. The estimated

exposures are below the level where elevated risks are observed in the epidemiologic studies that underlie the regulatory risk models (i.e., in the zone of inference of the dose-response curve). The risks are also predominantly below levels that are routinely accepted by EPA or experienced in daily activities, and are not of significant concern.

Several studies were identified that provide personal exposure measurements for maintenance workers engaging in activities that could potentially disturb ACM in buildings. The measurement data demonstrate that the vast majority (98.7%) of asbestos exposures during routine maintenance activities associated with in-place ACM are below the Permissible Exposure Level (PEL) of 0.1 fibers/cc for an 8-hour time-weighted average set by the Occupational Safety and Health Administration (OSHA) and none of the 30-minute values exceeded the OSHA 30-minute excursion limit of 1 fiber/cc. The OSHA PEL is the operative regulatory standard for workers.

Additionally, the exposure studies include information about the amount of time workers may spend in contact with ACM. The exposure concentration and exposure duration information provide the basis for estimating the lifetime dosage of asbestos from contact with ACM in buildings. Therefore, a risk assessment using U.S. Environmental Protection Agency (EPA) methodologies can also be conducted to provide an upper-bound, hypothetical estimate of the lifetime risk. For this risk assessment, both typical and high-end scenarios were considered, with higher exposure durations considered for the high-end scenario. The exposure estimates were combined with the cancer potency value developed by EPA to provide upper-bound estimates of lifetime cancer risk associated with ACM exposures. As is typical, the risk assessment employed conservative assumptions (i.e., assumptions that would tend to overestimate risk), which must be accounted for in interpreting the results.

The estimated risks were virtually all within levels that are considered acceptable by the governmental regulatory agencies. First, the risks are well below the risk level associated with the OSHA PEL, as expected given the comparisons with the PEL. Second, the exposures to maintenance workers are below the level where elevated risks are observed in the epidemiologic studies that underlie the regulatory risk models (i.e., in the zone of inference of the dose-

response curve). Finally, although exposure to maintenance workers is governed by OSHA, the estimated risks are predominantly below risks routinely accepted by EPA and associated with common daily activities.

My risk assessment uses asbestos exposure data that are not specific to potential exposure associated with Grace products, but instead considers exposure to all ACM materials in buildings. Therefore, the resultant risk estimates likely overestimate the potential contribution from Grace products only.

<u>Conclusion 3</u>: *The available exposure data for prevalent concentrations in buildings with ACM were reviewed and used to represent exposures to building occupants (e.g., office workers). Generally, the prevalent asbestos concentrations in buildings with ACM are so low that they cannot be differentiated from ambient background levels. Using the exposure data for buildings as an upper bound of the asbestos concentrations from ACM, the estimated risk to occupants is very low, even at the upper bound; the actual risk could be considerably lower than the estimate, and may even approach zero, and is below the observed range of any effects. For these reasons, these risks are not of significant concern.*

There is a plethora of data available to estimate the exposure of occupants (e.g., office workers) who work in buildings with ACM but do not come in direct contact with ACM. These data show that the concentrations within buildings with ACM are statistically indistinguishable from background concentrations outdoors. Therefore, the true contribution of asbestos from ACM indoors is too small to be estimated. However, assuming indoor asbestos exposures from the available measurements, and typical and high-end exposure durations for office workers, the estimated risks are very small and are not of significant concern compared to the range of risks considered acceptable by EPA. Additionally, the estimated risks are lower than many other environmental risks and other common risks that are accepted routinely by people in their everyday lives. This conclusion is consistent with EPA's view that ACM in buildings does not present a significant risk to occupants when it is left undisturbed (U.S. EPA 1988, 1990; HEI-AR 1991). As with the maintenance worker risk estimates, these estimates include contributions from all ACM products. Moreover, the exposures for building occupants are below the level

where elevated risks are observed in the epidemiologic studies that underlie the regulatory risk models (i.e., in the zone of inference of the dose-response curve). Thus, the risk estimates overestimate the potential contribution from Grace products only and represent a hypothetical, upper-bound risk based on conservative, health-protective assumptions.

Conclusion 4: *The claimants have not conducted a risk assessment. Therefore, they have failed to provide any scientific basis to demonstrate the plausibility of adverse health effects being associated with exposure to in-place ACM.*

The claimants have not assessed the risk associated with ACM. For the most part, the claimants have presented some personal air exposure measurements and dust measurements, without providing any context within which the data should be interpreted. There is a common saying in the medical literature—"the dose makes the poison"—which dates back to the Enlightenment. This reference essentially means that the potential for disease to result from any type of exposure is a function of the frequency, duration, and magnitude of the exposure. The claimants have failed to consider the frequency and duration of exposure and have not even attempted to estimate risk. Therefore, the claimants have not provided any scientific evaluation to show that exposures to building occupants and maintenance personnel associated with in-place ACM are harmful. Also, the claimants rely on dust measurements that do not reflect the asbestos concentrations that people breathe and cannot be used in risk assessment.

3 Bases for Conclusions

3.1 Grace sold two types of asbestos-containing sprayed-on surfacing products through the early 1970s—Monokote 3 (1959–1973) and Zonolite Acoustical Plaster (1945–1973)—that were used in building construction.

Grace sold two types of sprayed-on surfacing products that contained commercially added asbestos and were used in building construction. Monokote-3 (MK-3) was a spray-on fireproofing material for use on steel beams in construction. It was on the market in the U.S. from approximately 1959 to 1973 and in Canada until 1975. Chrysotile asbestos was added to a vermiculite and gypsum base to form MK-3. Zonolite Acoustical Plaster and a number of sub-product brands were on the market from approximately 1945 to 1973. Those spray-on products contained vermiculite (percentages varied across different sub-product brands), and commercially added chrysotile. Some of this sprayed-on surfacing material is still in place today.

This report addresses the exposures associated with building maintenance personnel who may perform activities that disturb in-place asbestos-containing materials (ACM), thereby releasing asbestos fibers, and exposures of building occupants who are not engaged in ACM-contact activities but work in buildings with ACM (e.g., office workers). Corn provides a history of scientific and regulatory activity related to exposures of asbestos in buildings (Corn, 2006). The assessment does not consider the exposures to asbestos abatement contractors who may have been involved in large-scale ACM removal.

3.2 Risk assessment is the accepted scientific method for evaluating the potential risk of disease associated with asbestos exposure to maintenance workers and building occupants.

3.2.1 Risk assessment can be applied to evaluate the likelihood that asbestos exposures in buildings may result in future disease.

A health risk assessment can establish whether a potential exposure is at least plausibly linked to adverse health effects. In a risk assessment, the estimated exposures can be compared to health benchmarks (e.g., an OSHA standard or an EPA potency estimate) to determine the likelihood that the exposure could result in an adverse health effect. Risk assessment is a scientifically accepted methodology that is used widely by federal, state, and local U.S. agencies and international organizations to address issues of potential health effects.

The claimants' experts in this case have not conducted a health risk assessment to determine the plausibility of adverse health effects being associated with ACM-related exposures in buildings. The data they have presented do not describe exposure and they have made no attempt to use it to estimate exposure and risk. Therefore, they have failed to provide any scientific basis to demonstrate the plausibility of adverse health effects being associated with ACM-related exposure.

3.2.2 The National Research Council of the National Academy of Sciences established a paradigm for conducting risk assessments, which is widely accepted by the scientific community and applied by governmental organizations in the U.S. and internationally.

In 1983, the National Research Council (NRC) published a document titled, *Risk Assessment in the Federal Government: Managing the Process* (NRC 1983). At the time, I was the Director of the Office of Health and Environment Assessment at EPA, and I served as an advisor to the committee and a reviewer for that document. The document established health risk assessment

as the acceptable approach for assessing the health risk associated with exposure to environmental substances. It is now considered an essential text for health risk assessment. The document outlined a four-step process for risk assessment:

1. *Hazard identification*: identification of a compound as a potential hazard based on animal toxicity studies or human epidemiologic studies

2. *Dose-response assessment*: assessment of the dose required to cause particular health effects

3. *Exposure assessment*: estimation of the exposure to the compound from the particular activity in question

4. *Risk characterization*: characterization of the evidence that an agent might be a human carcinogen (or cause other noncancer effects), together with a comparison of the exposure and dose-response to estimate the potential risk, accounting for uncertainties.

This four-step process is now often referred to as the "risk paradigm," and is widely accepted and applied by governmental authorities throughout the world and by the scientific community.

Public health agencies have taken a next step to adopt guidelines for addressing uncertainties in the risk assessment process. When scientific data are absent, assumptions that incorporate defaults are used to place an upper bound on risk. These results can be useful for determining whether low risks are meaningful; these approaches are not appropriate for establishing causality.

3.2.3 Risk assessment is a process that governmental regulatory agencies use to make judgments about population risk as part of a public health protective mandate.

Governmental agencies use risk assessment in making decisions about potential risk. For example, risk assessment is used to assess the risk associated with new products (to judge

whether they should be approved for use), hazardous waste sites (to determine if they should be remediated), or the construction of new industrial facilities (to determine if emissions or effluents will cause an unacceptable public health risk). The decision whether to leave asbestos-containing materials in place or to remove them is a similar decision process. In making such a decision, regulatory agencies would apply such a process to estimate the potential risk associated with leaving the materials in place (and possibly any added risk associated with removing the materials). If the risk of leaving the material in-place was unacceptably high, the agency may decide to remove the material to reduce the risk.

When applied in a regulatory setting, risk assessment is a conservative, health-protective process because it uses default assumptions that are intended to overestimate risk to account for scientific uncertainties. This approach is often termed the precautionary principle. Under this precautionary principle mandate, these public agencies charged with public health protective policies are essentially asking: is it possible that there is any risk, and, if so, what is the estimated magnitude of this risk of disease. Even when an agency determines that there is a risk, it does not necessarily mean that any actual disease will occur. For example, if an Agency estimates a risk of 1 in 1 million and a population of 10 million are exposed, one cannot make the leap to conclude that 10 people would be expected to have a disease outcome. The conservative process of regulatory risk assessment is biased to overestimate the risk. When an agency finds an elevated risk, it simply means that the agency believes that there is a chance that a risk could occur, and out of precaution, may act to remediate the risk (or not allow it to occur in the first place, if a new product or facility is the issue).

3.2.4 The claimants in this case did not attempt to conduct a risk assessment, and have not provided any rigorous analysis that demonstrates the plausibility of asbestos exposure of building occupants or maintenance personnel leading to adverse health impacts.

The claimants in this case do not provide a risk assessment or any other attempt to compare the exposures that maintenance workers or building occupants may encounter to relevant asbestos toxicity criteria or occupational standards. In a report by claimant expert Dr. William Longo, a small data set is presented (Longo 2006), but most of the data are not appropriate for developing a risk assessment. Much of Dr. Longo's data are from analyses of dust samples, which do not reflect the amount of respirable asbestos in the air and are not relevant to risk assessment (see Section 3.3.3). Also, in some cases, instead of simulating a typical maintenance activity, Dr. Longo collected air samples using artificial methods to disturb dust. For example, Dr. Longo presents some data for "dust reentrainment trials" associated with in-place Monokote-3. Dr. Longo used compressed air to "blow off" dust on top of a metal HVAC duct or used a hand brush to re-entrain dust from on top of another metal HVAC duct.

The state-of-the-art methodology for assessing the exposure associated with certain activities is to monitor the exposure of a worker while they perform the activity (generally called an exposure simulation). The measurements made by Dr. Longo do not represent simulations of actual worker activities; therefore, these data are less useful for risk assessment than simulation data. Additionally, some of Dr. Longo's air measurements were made using the TEM indirect filter preparation method, which can lead to artificially high fiber counts, particularly for chrysotile (HEI 1991). Dr. Richard Lee also details some other problems with Dr. Longo's measurement methodologies that render the data unusable for a scientifically valid risk assessment (Lee 2006; Lee 2007). I have not used the data collected by Dr. Longo in this risk assessment, because these data generally are not relevant for risk assessment, and other, better data sources are available.

3.3 The risk assessment paradigm is the accepted methodology that can be used to address the potential risk associated with asbestos exposures in buildings.

3.3.1 Hazard identification: The weight of evidence that asbestos causes cancer in humans is based on a series of epidemiologic studies in which workers or other highly exposed individuals were exposed to asbestos at high concentrations, with frequent exposures over a considerable period of time.

It is widely known and accepted that repeated exposures to high concentrations of asbestos over a long period of time may result in lung cancer and mesothelioma. EPA classifies asbestos as a Class A carcinogen, or a known human carcinogen, based on epidemiologic data gathered from exposures in the workplace.[1] OSHA has developed standards for asbestos exposure in workplaces. Additionally, repeated exposure to high levels of asbestos is associated with asbestosis, a chronic inflammation of the lung.

The health effects associated with asbestos exposure are known as the result of numerous epidemiologic studies on workers in the asbestos industry, who were exposed to very high levels of asbestos over long periods of time. The asbestos levels found in buildings are orders of magnitude lower than the levels found to be associated with health effects in the epidemiologic literature.

3.3.2 Dose-response assessment: The EPA has published a review of asbestos health-effect studies and has developed a recommended potency value for estimating the theoretical risk associated with a given asbestos exposure. Use of the EPA cancer potency value provides a conservative, upper-bound estimate of the risk.

Simply stating that asbestos is associated with adverse health impacts is not sufficient to conclude that there will be adverse health effects associated with exposure to asbestos from

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[1] http://www.epa.gov/iris/subst/0371.htm

ACM in buildings. The manifestation of adverse health impacts depends on the frequency, duration, and magnitude of exposure, which is commonly expressed as, "The dose makes the poison." The asbestos exposure associated with ACM in buildings is orders of magnitude lower than the exposures of the asbestos workers who were found to have elevated levels of disease. Therefore, it is necessary to estimate the likelihood of adverse health effects as a function of the actual exposure to asbestos from ACM in buildings.

Both OSHA and EPA have developed dose-response assessments for asbestos. OSHA, the regulatory agency responsible for worker protection, evaluated epidemiologic data for asbestos and set the PEL of 0.1 fibers/cc over 8 hours based on the epidemiologic data. OSHA also set an excursion limit of 1 fiber/cc for 30 minutes. EPA does not set an acceptable exposure limit. Instead, EPA has developed a potency estimate for asbestos that is expressed as the risk per fibers/cc of asbestos exposure averaged over a lifetime. The EPA approach provides a more generalized methodology that can be used to estimate a risk given a lifetime average exposure for individuals who may be exposed to varying concentrations, frequencies, and durations.

The EPA dose-response assessment is contained in its Integrated Risk Information System (IRIS).[2] EPA uses IRIS widely for internal risk assessments that are conducted during the regulatory decision-making process. Other governmental agencies, state agencies, and members of the scientific community also use IRIS frequently. The EPA IRIS file for asbestos reviews the available human epidemiologic and animal toxicology data. The file is based on the 1986 risk assessment for asbestos that was prepared by my office during my tenure at EPA. Based on this review, the IRIS file recommends a cancer risk value of 0.23 per fiber/cubic centimeter (f/cc) (averaged over a lifetime), based on the human epidemiologic data and using an exposure metric called PCM-equivalent (discussed in the exposure assessment section that follows). The value represents a probability of developing cancer for a lifetime average exposure of 1 f/cc. It is important to note that the risk factor is intended to be compared only with the average exposure over a lifetime. Therefore, periods where there is no exposure to asbestos must be accounted for when developing this average value. The occurrence of cancer from exposures to

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2 http://www.epa.gov/iris/

toxic substances is generally the result of prolonged, elevated exposures. Thus, the total exposure over a lifetime must be taken into account.

The EPA cancer risk potency represents a theoretical risk that is likely higher than the actual risk, particularly for the low exposures associated with ACM. For example, in the EPA model, the cancer risk is assumed to be linear with exposure; thus, for example, if the exposure is decreased by six-fold, the risk is also assumed to decrease six-fold. EPA adopted this approach in 1976 to place a plausible upper bound on the risk, meaning that the real risk could be considerably lower, even approaching zero. In fact, at doses lower than those in the epidemiologic studies that were used to estimate the IRIS potency factor, the risk could be considerably lower, even approaching zero. The linear assumption is conservative, and is made to be precautionary and protective of public health, as prescribed by environmental statutes. The range of possibilities is illustrated in Figure 1, which shows a zone of observation where epidemiologic data are available, and a zone of inference where conservative assumptions are made to estimate risk[3]. EPA makes the conservative, default assumption that the risk is linear in the zone of inference and that there is no threshold (see dark, straight dashed line) but, below the observed range, other dose-response curves are possible, as illustrated in the figure (lighter, curved dashed lines), including a threshold response where there is no risk below a certain level. OSHA also made a similar assumption in developing the PEL.

[3] More details on this zone of inference can be found in my report in personal injury case (Anderson, 2006).

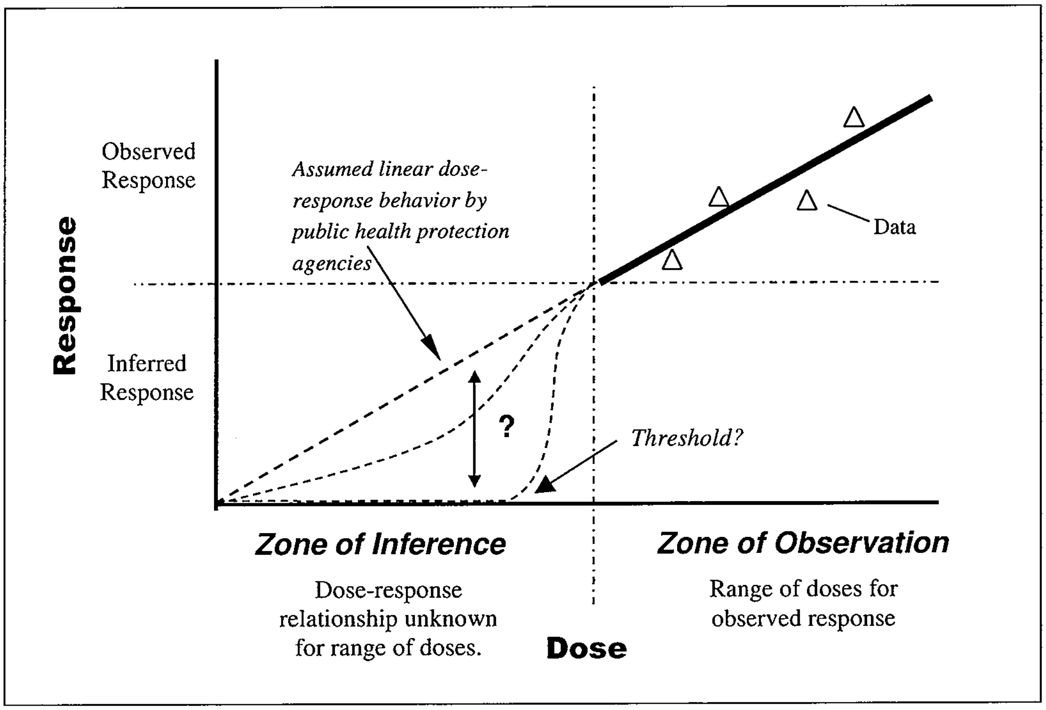

Figure 1. Zones of inference and observation in dose response

Without actual evidence of low-dose responses, the linear non-threshold model cannot be validated below the range of observed response. EPA acknowledges that the low dose response is uncertain and stated this clearly in its 1986 Cancer Risk Assessment Guidelines (U.S. EPA 1986b, p. 13):

> "It should be emphasized that the linearized multistage procedure [the most common no-threshold model] leads to a plausible upper limit to the risk that is consistent with some proposed mechanisms of carcinogenesis. Such an estimate, however, does not necessarily give a realistic prediction of the risk. The true value of the risk is unknown, and may be as low as zero."

Further, in the 2005 Guidelines for Carcinogen Risk Assessment, in the absence of mechanistic data that could be used to define the low-dose relationship, EPA recommends the following default position in assessing chemical carcinogenicity (U.S. EPA 2005, p. 3-21):

> "When the weight of evidence evaluation of all available data are insufficient to establish the mode of action for a tumor site and when [it is] scientifically plausible based on the available data, linear extrapolation is used as a default approach, because linear extrapolation generally is considered to be a health protective approach."

Others have supported this view. For example, in their review, Hodgson and Darnton (2000) state, "The standard assumption is that, other things being equal, the risk will be proportional to dose; but this is more a cautious default assumption than anything more soundly based." In fact, Hodgson and Darnton developed formulas for low-dose risk estimation that depart from the linear assumption and are more consistent with the low dose curves shown generically in Figure 1.

EPA echoes the concept of low-dose uncertainty specifically for asbestos in buildings, stating that "at very low exposure levels, the risk may be negligible or zero" (U.S. EPA 1990).

The level of exposure that causes asbestosis is generally considered to be higher than the level that causes cancer (U.S. EPA 1986a). Therefore, a risk assessment based on cancer potency should also be protective for asbestosis.

3.3.3 Exposure assessment: Numerous studies have measured exposures incurred by maintenance workers during disturbance of ACM in buildings and to occupants of buildings with ACM. The nature of the sample collection and asbestos measurement methodology is important for assessing the appropriateness of any measurement data for use in a scientifically reliable risk assessment.

1. The appropriate measurement of exposure is the concentration of airborne fibers. No information about risk can be obtained from dust measurements.

The EPA cancer risk factor is based on the inhalation exposure to airborne asbestos fibers greater than 5 microns (μm) in length, as is the OSHA PEL. Therefore, airborne asbestos fiber concentration is the only appropriate metric for exposure assessment. Moreover, only those particles of respirable size that are in the breathing zone are relevant to a proper risk assessment. Sometimes, dust measurements, including a percentage or quantification of the dust that is asbestos, are reported. While dust measurements may be useful for determining the presence of asbestos, dust measurements are not useful for quantitative risk assessment.

2. For a proper comparison with the EPA cancer risk factor, exposure measurements must be collected using phase contrast microscopy (PCM) or, ideally, transmission electron microscopy (TEM) converted to an equivalent value for PCM, or a PCM-equivalent (PCME). PCM cannot distinguish between asbestos and non-asbestos fibers. Accordingly, in environments in which non-asbestos fibers are present, a PCM measurement will overestimate the number of asbestos fibers.

Two microscopic techniques are commonly used for measuring asbestos fibers collected in air samples—PCM and TEM. TEM is the most sensitive measurement technology; it can detect thinner fibers and can differentiate between asbestos and non-asbestos fibers. The PCM method cannot distinguish between asbestos and non-asbestos fibers. Historically, most exposure measurements from the epidemiologic studies that formed the basis of the EPA cancer risk factor were done using PCM. Therefore, the EPA risk factor and the OSHA PEL are based on asbestos fiber counts using PCM. The PCM measurements in the epidemiologic studies were

made in environments with large amounts of asbestos; thus, the inability to differentiate asbestos and non-asbestos fibers did not significantly affect these fiber counts. By contrast, PCM measurements in non-occupational or mixed-fiber environments, such as in commercial buildings and homes, where types of structures other than asbestos are present (e.g., paper cloth, or non-asbestos minerals) will result in overestimates of asbestos fiber counts and, in turn, overestimated risks.

In this case, the available exposure data for maintenance activities are all in PCM. These PCM data reflect both asbestos and non-asbestos fibers, because the technique cannot distinguish between different fiber types. The risk estimates in this report for maintenance activities are based on PCM data from environments in which the presence of non-asbestos fibers is highly likely to be in meaningful amounts, and thus, the risk values are likely overestimated.

3. <u>The asbestos concentration can be overestimated if the indirect method for TEM sample filter preparation is used. The direct TEM filter preparation technique should be used for the most accurate results.</u>

Sometimes, filters collected in dusty environments can be overloaded if an improper sample volume is collected. In these situations, some microscopists use the "indirect preparation" method, which involves manipulating the filter, such as through sonication, to produce a suspension of particles in a liquid transfer medium, which is then transferred onto a new filter for analysis. This indirect preparation can lead to artificially high fiber counts (HEI 1991). This manipulation can result in an overestimate of the actual asbestos concentration in the air. For this reason, these data are not usable for risk assessment.

4. <u>Average exposures are the appropriate short-term sampling metric for estimating lifetime exposures.</u>

To estimate lifetime risks using the EPA IRIS factor, the lifetime average exposure needs to be estimated. All of the available exposure measurements for ACM involve short-term sampling (8 hours or less). As expected, repeated measurements of the same activity produce a range of

values, due to a myriad of factors involving the exact activities performed, the sequence of the activities, the nature of the ACM, etc. It is not appropriate to estimate a lifetime average exposure based on the upper end of a distribution of short-term measurements. For any individual who is exposed numerous times from a given activity, the best estimate of their total exposure over the course of these activities is the average exposure concentration from the short-term samples, multiplied by the total exposure duration. The individual's lifetime average exposure is the cumulative lifetime exposure divided by the length of a lifetime, which for risk assessment purposes is assumed to be 70 years.

3.3.4 Risk characterization: OSHA and EPA and other regulatory authorities have established criteria for assessing the acceptability of risks, which can be applied to characterize the magnitude of the risk associated with ACM in buildings.

For workers, the relevant risk standard is the PEL set by OSHA. The PEL is based on an 8-hour exposure period. However, the short-term nature of the PEL is typical of OSHA standards and is used to determine compliance. The appropriate period for assessing health risk under EPA methodology for asbestos exposures is lifetime average exposure. In developing the PEL, OSHA estimated that the risk associated with 45 years of occupational exposure at its PEL for asbestos of 0.1 fibers/cc was 3.4 per 1000 (or 3.4×10^{-3}).

Interpreting the results of an assessment using EPA's upper-bound risk methodologies is based on the same principles but takes account of the specific exposures and risk for the circumstance being considered. After developing quantitative estimates of risk, or placing an upper bound on the probability of an individual getting a disease as a result of an exposure, it is necessary to establish what risk is acceptable. It must be understood that we accept risks in our everyday lives, from driving to work to what we eat, or how we spend our recreational time; in many instances, there are actual risks that can be derived from incidence data. As such, these fact-based risks are far more certain than the hypothetical cancer risks established by the methodology used by EPA and other public health agencies. Nevertheless, regulatory authorities are concerned with risks that are considered unacceptable to citizens. The definition

of an acceptable risk is a value judgment that takes into account many factors, including the uncertainty in the assessment, the costs of remedial action, and the magnitude of risks that are generally perceived to be acceptable to individuals. To interpret the EPA-based risk methodology results, this report relies on ranges of acceptable risk that are established by EPA and used in EPA pubic health–protective, regulatory actions.

For carcinogens, EPA has set forth and supports an acceptable range of individual excess risk due to cancer of 10^{-6} (one in a million) to 10^{-4} (one in ten thousand). It should be noted that the background risk of dying from cancer of all causes is approximately 14% (see Section 3). Thus, an excess risk of 10^{-4} (0.01%) results in a total risk of 14.01%. For example, the National Contingency Plan (NCP) sets forth the procedures that must be followed by EPA and private parties in selecting and conducting Superfund response actions.[4] The NCP defines the acceptable risk range as follows:

> "For known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response."

EPA expanded on its definition of the acceptable risk range in 1991 in its document, *The role of baseline risk assessment in Superfund remedy selection decisions* (U.S. EPA 1991a):

> "For sites where cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, action is generally not warranted, but may be warranted if a chemical specific standard that defines acceptable risk is violated or unless there are noncarcinogenic effects or an adverse environmental impact that warrants action."

The acceptable risk range has also been adopted by other programs within EPA, including the drinking water (Cotruvo and Vogt 1990) and air (NRDC v. EPA 1987) programs.

In the decision established through the NRDC v. EPA case, often referred to as the Benzene Decision, EPA adopted a presumptively safe risk level of 10^{-4}. Furthermore, in setting this risk level, EPA noted that as risk increases incrementally above the benchmark of 10^{-4}, it becomes "presumptively less acceptable." In establishing this level, EPA stated that the 10^{-4} risk level is not a "rigid line for acceptability," but that the "Agency intends to weight it with a series of other health measures and factors" when making a decision (54 Federal Register 38044).

3.4 A large number of asbestos air samples collected in commercial buildings can be used to assess risk associated with potential exposure to individuals that have worked in these buildings.

Sampling data fall into two general categories: 1) samples collected during normal building activity to measure prevalent levels in buildings, and 2) samples collected to measure the exposure of maintenance workers while engaged in routine maintenance and repair activities.

The air sampling data set used in the risk assessment is not specific to potential exposure associated with Grace products, but instead considers exposure to all ACM materials in buildings. Therefore, the resultant risk estimates likely overestimate the potential contribution from Grace products only.

3.4.1 Three U.S. studies were identified that have measured prevalent exposure of building occupants to asbestos during normal building activity.

Crump and Farrar (1989) reported asbestos concentrations measured in a 1987 EPA study of 49 General Services Administrative buildings (referred to as the GSA study) in five geographic regions of the United States. The GSA study involved collection of 387 samples of airborne asbestos from inside or immediately outside 49 public buildings. Six of the buildings contained

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[4] NCP, the National Contingency Plan (NCP, 40 Code of Federal Regulations 300.430(e)(2)(i)(A)(2)).

no known friable ACM, while six contained ACM in good condition, and 37 contained damaged ACM. The study found no statistically significant differences in airborne asbestos levels, either between indoor and outdoor levels or among buildings that contained no known asbestos, asbestos in good condition, or damaged asbestos materials. The average concentration of fibers longer than 5 μm measured within buildings was reported as 0.00007 fibers per cubic centimeter (f/cc) (PCM-equivalent).

Corn et al. (1991) published a study of 71 Texas school buildings in which a total of 473 air samples were collected. The sampling was designed to collect at least one set of samples at high-, moderate-, and low-activity indoor areas, in proximity to ACM and in areas with no ACM. No significant differences were reported between the concentrations detected using personal versus area samples. Additionally, Dr. Corn noted that no correlation was observed between asbestos concentration in air and numerous other factors, including the type of ACM present, the condition of the ACM, its accessibility to students, whether or not the ACM was covered, air flow, whether or not sweeping was noted, type of school, and year of construction. The average level of fibers longer than 5 μm in these school buildings was 0.00017 f/cc (PCME).

In a study published by Lee et al. (1992), more than 2500 air samples were collected from 315 public, commercial, school, and university buildings over a 5-year period. The majority were area samples, with 106 personal samples. A portion of the Lee data included the 71 buildings previously reported by Corn (1991). Table 1 presents the numbers of buildings and samples, and the average levels of fibers longer than 5 μm (PCME).

Table 1. Summary of buildings sampled and average level of fibers longer than 5 μm (PCM-equivalent) reported by Lee et al. (1992)

Building Type	Number of Buildings	Number of Samples	Average (f/cc)
School	177	921	0.00011
University	78	426	0.00007
Commercial	28	213	0.00002
Public	32	123	0.00007
Personal		106	0.00009
Outdoor		759	0.00002

Taken as a whole, the various building studies encompass nearly 3,000 indoor samples collected by government agencies, individual researchers, and building owners. Others have evaluated and summarized asbestos concentrations in buildings and come to similar conclusions (U.S. EPA 1988, 1990; HEI-AR 1991). The data present a consistent picture of uniformly low indoor ambient asbestos concentrations in occupant settings, and the concentrations are often indistinguishable from background ambient levels.

3.4.2 Several studies were identified that measured asbestos exposure representative of maintenance workers engaged in routine maintenance and repair activities.

Price et al. (1992) provided a statistical evaluation of exposure data that were placed on the 1986 docket for the OSHA General Industrial Asbestos Standards. The data came from various organizations and represented 1,227 air samples collected during routine maintenance activities (Price et al. 1992). The activities that considered were routine maintenance activities, referred to at that time by OSHA as small-scale, short-duration (SSSD) tasks, including repair/maintenance of air-handing units, heat exchangers, and tanks; repair and replacement of pipe insulation, including removal of small amounts of ACM; valve or gasket replacement; installation of connections or extensions for telecommunication and computer networks or other electrical systems such as fire detectors; adjustment/repair of HVAC systems; repair or

replacement of lighting fixtures; and replacement of ceiling tiles. Samples were coded as "activities that take place in utility spaces," "activities above suspended ceilings where ACM is present," and "other." Although all data are used in the statistical summaries, Price indicates that some measurements may not reflect SSSD activities but are more related to removal of insulation, which is not the subject of this report.

Recent studies conducted by Mlynarek et al. (1996) reported personal exposures to asbestos in air for maintenance workers employed by a large U.S. metropolitan county government while performing a variety of tasks in 41 county buildings during the years 1988–1993. A total of 1,008 air samples were collected. The majority of personal samples were associated with the following activities: ACM debris cleanup, bulk sample collection, cable pulling, ceiling-tile replacement, electrical installation, electrical repair, fluorescent lamp replacement, high-efficiency particulate air (HEPA) vacuuming or wet wiping of dust and debris, and wet-wipe cleaning. Most of the maintenance tasks associated with ACM were performed above dropped, laid-in tile ceilings. Reported asbestos air concentrations for relevant maintenance tasks are summarized in Table 2. The mean personal air concentration for all tasks ranges from 0.02 to 0.35 f/cc by PCM. Airborne levels are consistent with those reported by Price et al. (1992), although some specific tasks, such as ceiling tile replacement, evaluated by Mlynarek et al. (1996), were associated with somewhat higher asbestos concentrations.

Table 2. Exposure to airborne asbestos during building maintenance or repair[a] (Mlynarek et al. 1996)

Material Abated	Number of Samples	Concentration Range[b] (f/cc)	Arithmetic Mean (f/cc)	Type[b]	Average Total Work and Sample Time (minutes)
Cable pull	36	0.011–0.20	0.048	Personal	89
Ceiling tile replacement	66	0.030–3.5	0.35	Personal	37
Electrical installation	14	0.010–0.11	0.037	Personal	91
Electrical repair	24	0.0034–0.052	0.02	Personal	203
Fluorescent lamp replacement	78	0.0054–0.065	0.025	Personal	150
HEPA vacuum/wet wiping dust/debris	14	0.029–0.30	0.098	Personal	131
TOTAL (range)	232	0.0034–3.5	0.020–0.35	Personal	37–203

[a] Analysis by PCM, NIOSH Method 7400

[b] Concentration only during sampling periods, not an 8-hr TWA that can be compared with the OSHA standard.

Corn et al. (1994) obtained personal samples in several buildings and reported concentrations for a variety of activities (see also Corn et al. 1995 for some corrections to the paper). The Corn et al. results are generally similar to the Mlynarek et al. results, with the notable exception that Corn et al. found lower concentrations for ceiling tile replacement than reported by Mlynarek et al.

Keyes et al. (1994) report simulations of installation, repair, remodeling, and maintenance tasks in buildings with ACM. Personal air samples were collected during simulated activities, and for some simulations, during the cleanup activity. The authors measured concentrations for fixture maintenance and ceiling tile activities (0.01–0.45 f/cc by PCM) similar to those reported by Mlynarek. However, far fewer samples were collected, and the TEM measurements were made using an indirect filter preparation (see earlier discussion). Also, Keyes et al. state that the simulations conducted in their study "examine situations where workers do not know about the presence of ACM, or where they either have not been trained or simply do not use work

practices specially designed for work around ACM." Therefore, these data would not be representative of buildings that follow Operations and Maintenance plans.

3.4.3 Commonly accepted risk assessment criteria were used to evaluate each of the exposure studies for scientific quality and appropriateness for use in assessing risk.

Several criteria were applied to assess the scientific quality of the studies and their usefulness for risk assessment:

1. *Appropriate exposure scenarios and adequate descriptions*: The study must evaluate exposure scenarios that are representative of building maintenance activities or provide prevalent asbestos concentrations in buildings with in-place ACM that are representative of building occupant exposure. These exposure scenarios must be described in sufficient detail to clearly understand the activity.

2. *PCM or PCME (PCM-equivalent) fiber counts*: The availability of PCM or PCME asbestos concentration data is a necessary exposure metric to make appropriate comparisons with the EPA IRIS potency factor. It is preferable to have PCME exposure metrics, because PCME accounts for the percentage of fibers that are actually asbestiform. However, PCM values can be used with the understanding that risks developed with PCM data in mixed fiber settings are quite likely to be overestimated.

3. *Other issues*: Other issues relevant to using the data for risk assessment include sample collection methods, measurement issues other than those mentioned above, and whether the study contains sufficient documentation.

The GSA (Crump and Farrar 1989), Corn et al. (1991), and Lee et al. (1992) studies all provide data representative of asbestos exposure to occupants in buildings during normal building activity. While Corn et al. (1991) focuses only on school environments, the GSA (Crump and

Farrar 1989) and Lee et al. (1992) studies provide measured concentrations for air in commercial buildings. The average concentration of fibers longer than 5 μm measured within buildings, as reported by Crump and Farrar, of 0.00007 f/cc (PCM-equivalent), can be used to represent asbestos exposure of occupants in buildings with ACM during normal activity. This value is also consistent with the range of values reported by Lee et al. (1992) for a variety of building types.

With regard to studies that measured asbestos exposure representative of maintenance workers engaged in routine repair activities, the Mlynarek et al. (1996) study provides the most extensive data set. Price et al. (1992), Mlynarek et al. (1996), and Corn et al. (1994) provide PCM data and sufficient detail on sampling methods. Mlynarek presents airborne concentrations and task durations for a variety of specific maintenance tasks, whereas Price presents airborne concentration ranges summarized for two general activity types, including "utility space" and "above ceiling." The Mlynarek study provides a representative set of exposure data that can be used to bound estimates of risk associated with various maintenance activities. The Corn data are very similar in magnitude to the Mlynarek data, but the Mlynarek data provide a more convenient summary for risk assessment purposes. Therefore, the risk assessment is based on the Mlynarek exposure data and a combination of the activity duration data from Mlynarek, Corn, Price, and the OSHA contractor, CONSAD Research Corporation (1985).

3.5 The workday average exposures reported in the studies can be compared with the OSHA PEL to determine compliance with occupational risk standards.

The OSHA PEL is 0.1 fibers/cc for an 8-hour time-weighted average and 1 fibers/cc for a 30-minute excursion period. The Mlynarek study provides the most comprehensive summary of TWA concentrations. The 8-hour TWA concentrations were calculated by Mlynarek by multiplying the exposure concentration by the task duration and divided by 8 hours. The data are included in Table 3 across different activities that maintenance personnel perform. The vast majority of asbestos exposures during routine maintenance activities associated with in-place

ACM are below the PEL; of 302 samples, only four 8-hour TWA values (1.3%) exceeded the PEL. None of the 30-minute values exceeded the excursion limit. The average 8-hour TWA across all of the samples was 0.014, which is nearly an order of magnitude below the PEL. The average 30-min excursion value was 0.12 fibers/cc, which is nearly an order of magnitude lower than the 30-minute excursion limit of 1 fiber/cc.

Table 3. Comparison of Mlynarek Data with OSHA Limits

Activity	Number of Samples	8-Hour TWA (>5 μm) (fibers/cc)	30-Minute Excursion Concentration (>5 μm) (fibers/cc)
ACM debris cleanup	9	0.0077 (0.0029–0.028)	0.056 (0.040–0.11)
Bulk sample collection	31	0.0042 (0.0023–0.024)	0.049 (0.037–0.060)
Cable pull	37	0.013 (0.0025–0.037)	0.098 (0.040–0.45)
Ceiling tile replacement	67	0.030 (0.0025–0.21)	0.31 (0.040–1.5)
Electrical installation	14	0.011 (0.0053–0.026)	0.083 (0.042–0.36)
Electrical repair	24	0.0091 (0.0026–0.027)	0.074 (0.038–0.29)
Fluorescent lamp replacement	78	0.0059 (0.0024–0.018)	0.050 (0.038–0.077)
HEPA vacuum/wet wiping dust/debris	17	0.026 (0.0028–0.073)	0.045 (0.045–0.046)
Wet wipe cleaning	25	0.0092 (0.0028–0.024)	0.084 (0.045–0.23)
Total	302		
Minimum (all samples)		0.018	0.046
Maximum (all samples)		0.21	1.5

These data show that exceedences of the PEL for maintenance and repair activities in buildings are very rare and that the average exposure for maintenance workers is nearly an order of magnitude below the PEL concentration. Additionally, the values reported in Table 3 are only for days when the worker engages in ACM contact. The available exposure duration data show

that workers only contact ACM infrequently. The Mlynarek data are consistent with the Corn study, which presented 8-hour TWA values across approximately 500 samples, and found no exceedences of the PEL when the samples were averaged by task category and building.[5] The calculations in the next section show that lifetime risks for maintenance workers are well below the risk level associated with the OSHA PEL.

3.6 A risk assessment can be conducted with the personal exposure data using EPA methods. The risks can be put into context, acknowledging the uncertainties in the assessment.

3.6.1 To estimate potential cancer risks, reasonable assumptions regarding frequency (hours per year) and duration (years) for occupant and maintenance-worker activities involving contact with asbestos-containing materials need to be established.

1. Introduction

As discussed throughout this report, the cancer risk associated with asbestos is dependent on lifetime exposure. The risk associated with a particular activity can be estimated as follows:

$$\textit{Cancer Risk} = \textit{Cancer Risk Factor} * \textit{Exposure} * \textit{TWF} \qquad (1)$$

where the *Cancer Risk Factor* is the EPA/IRIS value of 0.23 f/cc, the *Exposure* is the average asbestos airborne concentration over the time period of the activity, and the time-weighting factor (*TWF*) is the fraction of time over a lifetime that an individual engages in a particular activity. Under EPA guidance, a 70-year lifetime is typically assumed, which equals 25,550 days, or 613,200 hours. Therefore, for each activity, *TWF* can be estimated as follows:

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[5] All of the individual sample values are not included in the paper, likely due to brevity of presentation. Therefore, it cannot be stated that all of the values were below the PEL.

$$TWF = \frac{Cumulative\ hours\ engaged\ in\ activity}{613{,}200\ hours\ /\ lifetime}$$

There has not been a specific study on the hours that an occupant or maintenance worker might be engaged in specific activities over a lifetime. Therefore, conservative durations of exposure were developed based on available regulatory default exposure assumptions and review of the scientific literature on the duration of activities. It is recognized that individual behavior and work patterns differ. Therefore, to account for variation in exposure, and to facilitate calculation of central-tendency and upper-bound risks, "typical" and "high-end" exposure factors have been derived for both occupants and maintenance workers. This section provides the basis for the derivation of the activity-specific *TWFs* used in the risk assessment.

2. Maintenance-Worker Exposure Scenarios and Activity Times

TWFs were generated for six exposure scenarios that were selected to represent a range of typical maintenance activities and are illustrative of the most frequently performed activities based on review of the literature.

1. Cable pull — This involves work above suspended ceilings, such as connecting and extending telecommunications and computer networks.

2. Ceiling tile replacement — This activity generally occurs during new-tenant improvements or when tiles need to be replaced due to water damage. Additionally, ceiling tiles are often removed to perform maintenance or repairs in the space above the tiles. This removal and replacement is included in the activities that require it. The ceiling tile replacement scenario represents a complete removal of ceiling tiles and replacement with new tiles.

3. Electrical installation — This activity may include installation of electrical systems, such as smoke or heat detectors, and making connections to electrical systems, and often involves work above suspended ceilings.

4. Electrical repair — This scenario is similar to Scenario 3, but includes repair of systems.

5. Fluorescent lamp replacement — This activity includes replacing lamp fixtures beneath ceilings.

6. ACM debris clean up — This scenario includes cleanup of debris and dust during maintenance activities that involve the potential disruption of ACM materials.

Information on the frequency with which these representative maintenance tasks were performed historically is presented in studies by CONSAD (1985), Price et al. (1992), Corn et al. (1994), and Mlynarek et al. (1996).

Using building owner survey information, CONSAD Research Corporation (1985) presents exposure frequencies for nine maintenance tasks that potentially involve exposure to asbestos. Generally, these tasks overlap those investigated by Mlynarek et al. (1996). CONSAD provides both upper- and lower-bound estimates of average annual frequencies of performance for activities in residential and commercial buildings (combined) (CONSAD 1985, Table 5.2). CONSAD also presents activity-specific durations and crew sizes, which can be combined with the frequencies to provide the number of man-hours spent per task per year per building. For "repair/replace ceiling tiles"—the activity that the Mlynarek study found to generate the highest exposure concentrations—CONSAD gives the upper-bound average annual frequency as 2.5 times per year, with one worker taking 4 hours per event, resulting in 10 hours of exposure per year, if one assumes that one individual does all the work. For the task with the highest frequency of occurrence, "repair/adjust ventilation/lighting," two individuals are assumed to perform the two-hour task 4.1 times per year, resulting in 8.2 hours per worker per year. Inspection of the estimates for other activities suggests that an assumption of 10 hours per year for the average, or typical, exposure duration would safely cover the other CONSAD activity-specific findings. The typical value of 10 hours per year is consistent with other studies that provide exposure duration information, which is described below, and therefore, this value is used in my risk assessment as the annual exposure duration for the typical scenario.

In addition to average values, CONSAD provides information regarding the distribution of activity-specific frequencies across all buildings, which allows for high-end exposure frequencies to be approximated. For ceiling tile replacement, the high-end frequency, taken as the 90th percentile, is approximately 40 times over five years, or 8 times per year, which when combined with the 4-hour task duration, results in a high-end exposure duration of approximately 30 hours per year. The similarly derived upper-bound duration for a worker engaged in "repair/adjust ventilation/lighting" is also approximately 30 hours per year.

The use of the CONSAD data in risk assessment is potentially complicated by the fact that the CONSAD data are presented in terms of buildings and not workers. There is likely to be a positive correlation between the number of activities performed in a building and the building size and number of maintenance personnel that serve the building. Furthermore, there may be circumstances where a single maintenance person would serve multiple buildings. The upper-end exposure duration of 30 hours per year calculated for ceiling tile replacement above refers to a situation where a single maintenance person performs all of the work in a single building (at a frequency at or greater than 90% of all other buildings). While the number of workers servicing each building cannot be estimated from the CONSAD data, the upper-end frequency durations could also refer to a situation where several maintenance persons share responsibilities across multiple buildings.

Price et al. (1992) obtained information from building owners on frequency and duration of SSSD activities, to determine potential exposure hours per worker. Price presented potential exposure duration percentiles of 10.7 hours/year (25th percentile), 27.3 hours/year (median), 64.4 hours/year (75th percentile), and 332 hours/year (90th percentile). These values are equivalent to 0.5%, 1.4%, 3.2%, and 16.6% of a 2000-hour work year for all activities in all office buildings. The exposure frequencies in the Price et al. study are generally higher than those presented in other studies. The differences may reflect the different sampling populations in the studies or data collection differences. The upper-end of the range reported by Price et al. is discussed later in this report when the aggregate sum of activity specific exposure durations is discussed.

As part of an airborne asbestos sampling investigation of five buildings (commercial, bank, and medical center buildings), Corn et al. (1994) reviewed logs maintained by the building owners, in which the time that maintenance workers spent performing tasks above ceilings in proximity to fireproofing materials or other ACMs during the course of doing their jobs was recorded. The frequency and duration information was used by Corn et al. to estimate time-weighted exposures for individuals for which air monitoring was conducted. As shown in Table 4, over the time period evaluated for each building (13–89 weeks), the maximum proportion of time that any maintenance worker spent in tasks related to possible asbestos exposure was 3.3% (equivalent to 66 hours per working year).[6]

Table 4. Percentage of maintenance worker time with potential asbestos exposure (Corn et al. 1994)

Building	Period Covered (weeks)	Number of Individuals Engaged in Possible Asbestos Exposure Tasks	Percent Time Exposed
1	28	24	0.02–3.31
2	89	5	0.05–0.35
3	19	6	0.20–1.19
4	19	4	0.25–2.33
5	13	7	0.5–2.91

Finally, information presented in Mlynarek et al. (1996) allows the estimation of the percentage of maintenance-worker time devoted to tasks specifically associated with ACM. As summarized in Table 2, Mlynarek reports an average task time ranging from 37 to 203 minutes. Mlynarek et al. also indicates that the maximum number of times a personal sample was collected on any individual maintenance worker in the workforce in any given year was 22 times. Because samples were collected during all ACM activity, this value represents the maximum number of times that a worker may contact ACM. Therefore, using the low- and high-end task activity times, and assuming that a worker performs each activity 22 times, I have

[6] I am aware of the letter to the editor from Mr. Ewing and Dr. Keyes regarding this paper and the subsequent response by Dr. Corn, Dr. McArthur, and Mr. Dellarco in the *Applied Occupational and Environmental Hygiene*

calculated a range of 13–74 hours per year of possible ACM-related work. This range is consistent with the maximum value reported by Corn et al. (1994)—66 hours per working year (3.3%)—and is within the 25th and 75th percentile values reported by Price et al.: 10–64 hours per year of ACM-related work. Based on the maintenance activity information reviewed, I have assumed that the total amount of time that any maintenance worker spends on individual tasks related to possible asbestos exposure is 10 hours per year for a typical exposure scenario, and 66 hours per year for a high-end exposure scenario. This range is consistent with information estimated from the CONSAD report and the Mlynarek article and captures the maximum value reported by Corn et al. (66 hours for all tasks combined). The high-end value is also consistent with Price's upper 75th percentile. The typical value of 10 hours corresponds to approximately 0.5% of the work year and is roughly equal to the median exposed person considered in the Corn et al. (1994) study (for all tasks).

For some specific work-related tasks, such as ceiling-tile replacement, that occur only during new-tenant improvements or renovation, and fluorescent lamp replacements that occur infrequently, a high-end value of 30 hours per year is used, based on the CONSAD data (also Corn 2007, pers. comm.). Ceiling tile replacement is associated most commonly with renovation activities, instead of routine maintenance. Fluorescent lamp replacement is expected to be an infrequent activity, given that the current average lifetime of fluorescent bulbs and tubes is 6,000 to over 15,000 hours.[7] Therefore, it is expected that the exposure durations for these activities would be less than the other activities that were considered, because the other activities could occur in more routine day-to-day circumstances. It should be noted that, in the high-end scenario, the 30 hours assumed spent replacing ceiling tiles and fluorescent light bulbs occurs every year for 25 years, resulting in the worker spending about 5 months of their work tenure engaged full time in each of these activities.

In addition to the individual task activity durations, an aggregate duration for all tasks is assumed. For the aggregate calculations, the sum of the individual task durations is assumed

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Journal (Vol. 10, Number 6, June 1995). Dr. Corn noted that none of the corrections altered the conclusions of the original paper. The corrections also did not alter any of the conclusions of this report.

7 http://www.gelighting.com.

separately for the typical task duration and upper-end task durations. For maintenance workers who have multiple duties in a building, the performance of multiple tasks is likely typical. The sum of the typical task durations is 60 hours/year, which is similar to the upper 75th percentile presented in the Price et al. study. The sum of the high-end task durations is 324 hours per year, which is approximately equal to the 90th percentile duration from Price et al. of 332 hours per year. Thus, the high-end aggregate scenario covers the high end of the data set with the highest exposure durations.

Table 5 summarizes the basis for all of the exposure durations that are assumed in the risk calculations.

Table 5. Summary of maintenance activity frequency

Scenario	Frequency	Basis
Typical for specific individual activities	10 hours/year	CONSAD, 1985 – review of specific activities, including ceiling tile replacement
		Corn et al 1994 – Approximately equal to the median duration for all tasks in the Corn et al. (1994) study
Typical for combined activities (aggregate)	60 hours/year	Price et al 1992 – similar to the upper 75th percentile for all activities combined of 64.4 hrs/yr
		Corn et al 1995 – similar to maximum reported value for all activities combined of 66 hrs/yr
		Mlynarek et al 1996 – consistent with calculated range for all activities of 13–74 hr/yr
High end for specific individual activities	66 hours/year	Corn et al 1994 – maximum reported value maximum reported value for all activities combined of 66 hrs/yr
		Mlynarek et al. 1996 – within calculated range for all activities of 13–74 hrs/yr
		Price et al 1992 – similar to the upper 75th percentile for all activities combined of 64.4 yrs/hr
High end for ceiling tile replacement and ventilation/lighting (fluorescent light change)	30 hours/year	CONSAD 1985 – 90th percentile for ceiling tile activity of 30 hours per year
		CONSAD 1985 – 90th percentile for repair adjustment of ventilation and lighting of 30 hours per year
High end for combined activities (aggregate)	324 hours/year	Price et al 1992 – similar to 90th percentile of 332 hrs/yr

3. Occupant Exposure Scenario and Activity Time

For occupants, a typical value of 2,000 hours per year spent working is used, based on 8 hours per day and 250 working days per year. A high-end value of 2500 hours per year is used, based on the assumption of a 10-hour working day for 250 days per year.

4. Duration of Exposures (years)

Maintenance Workers — Maintenance workers' exposure durations reflect occupational tenure. The exposure duration for a typical contractor is assumed to be 11 years. This value is approximately the same as the median occupational tenure for electricians, a profession with high occupational tenure relative to other contractors (U.S. EPA 1997). The high-end value is 25 years, based on the regulatory default value used in Superfund risk assessment for the upper-bound lifetime job tenure for commercial workers (U.S. EPA 1991b).

Building Occupants — For activities that can be expected to occur regularly (e.g., annually), the years of exposure are based on the average and upper-bound values derived from occupational mobility studies. The median occupational tenure (number of years in one location) of the working population aged 16 years and older is 6.6 years (Carey 1988), and this value is assumed for the typically exposed occupant. The default commercial value of 25 years for the upper-bound lifetime job tenure is used for a high-end exposed occupant (U.S. EPA 1991b). In this case, it assumes that an individual spends the entire period working in a building with ACM.

5. Time-Weighting Factors

The amount of time that is assumed to be spent by typical and high-end exposed maintenance workers involved in potential asbestos-disturbing activities, and the corresponding TWFs (expressed as percentage of a lifetime), are shown in Table 6, which also presents the TWFs for the typical and high-end commercial occupant worker.

Table 6. Summary of estimated exposure frequency and durations, and TWFs for maintenance activities and commercial occupants

Activity	Scenario	Exposure Frequency (hours/yr)	Exposure Duration (years)	Time-Weighting Factor (%)
Maintenance activity – cable pull	Typical	10	11	0.018%
	High-end	66	25	0.27%
Maintenance activity – ceiling tile replacement	Typical	10	11	0.018%
	High-end	30	25	0.12%
Maintenance activity – electrical installation	Typical	10	11	0.018%
	High-end	66	25	0.27%
Maintenance activity – electrical repair	Typical	10	11	0.018%
	High-end	66	25	0.27%
Maintenance activity – fluorescent lamp replacement	Typical	10	11	0.018%
	High-end	30	25	0.12%
Maintenance Activity – ACM debris cleanup	Typical	10	11	0.018%
	High-end	66	25	0.27%
Commercial occupant	Typical	2000	6.6	2.15%
	High-end	2500	25	10.19%

3.6.2 Using the exposure data that represent maintenance worker and occupant activities and exposure duration assumptions, plausible upper-bound lifetime cancer risks can be estimated for each exposure scenario using the recommended EPA dose-response model for asbestos.

The risk estimates for each maintenance worker activity and a commercial occupant are summarized in Table 7. For each scenario and type of exposed individual, the typical and high-end exposures were estimated. For maintenance activities, risks were estimated for the separate activities. Additionally, the aggregate risk of all these activities (i.e., combined risk) was also calculated and assumes that a worker continually engages in all these activities over their

occupational tenure. By calculating an aggregate risk, I have essentially increased the overall exposure frequency (hours/year) of maintenance activities.

Table 7. Estimated plausible upper-bound risks for maintenance workers

	Scenario	Maintenance Activity Exposure Concentration (f/cc)[a]	Time-Weighting Factor (%)	Cancer Risk Factor $(f/cc)^{-1}$	Plausible Upper-Bound Risks	Plausible Upper-Bound Risks With 10× PPE factor
Maintenance Activity – Cable pull	Typical	0.048	0.018%	0.23	2.0E-06	2.0E-07
	High-end	0.048	0.27%	0.23	3.0E-05	3.0E-06
Maintenance Activity – Ceiling tile replacement	Typical	0.35	0.018%	0.23	1.4E-05	1.4E-06
	High-end	0.35	0.12%	0.23	9.8E-05	9.8E-06
Maintenance Activity – Electrical installation	Typical	0.037	0.018%	0.23	1.5E-06	1.5E-07
	High-end	0.037	0.27%	0.23	2.3E-05	2.3E-06
Maintenance Activity – Electrical repair	Typical	0.02	0.018%	0.23	8.3E-07	8.3E-08
	High-end	0.02	0.27%	0.23	1.2E-05	1.2E-06
Maintenance Activity – Fluorescent lamp replacement	Typical	0.025	0.018%	0.23	1.0E-06	1.0E-07
	High-end	0.025	0.122	0.23	7.0E-06	7.0E-07
Maintenance Activity – ACM debris cleanup	Typical	0.074	0.018%	0.23	4.0E-06	4.0E-07
	High-end	0.074	0.27%	0.23	6.1E-05	6.1E-06
Commercial occupant	Typical	0.00007[b]	2.2%	0.23	3.5E-07	na
	High-end	0.00007[b]	10.2%	0.23	1.6E-06	na

[a] Mlynarek et al. (1996), Table 10, mean concentration

[b] Crump and Farrar (1989).

na – not applicable

For a maintenance worker, the lifetime risks for each of these scenarios are well below the risk level associated with the OSHA PEL. Moreover, all risks are within EPA's risk range of 10^{-4} to 10^{-6}. The plausible upper-bound risks associated with potential asbestos exposure for various maintenance tasks ranges from 8.3×10^{-7} to 1.4×10^{-5} for the typical scenario and from 7.0×10^{-6}

to 9.8×10^{-5} for the high-end scenario. These risk estimates are based on airborne concentration data obtained in the breathing zone of workers. Although workers were not required to wear respirators for many operations, air-purifying cartridge respirators were often provided in the buildings, and Mlynarek et al. indicates that nearly all employees wore half-face air-purifying respirators during the maintenance activities they reported. Use of half-face respirators for some maintenance activities is consistent with the interim and final OSHA standard (CFR 1910.1001, June 20, 1986 and August 10, 1994). A reasonable assumption is that the use of half-face air-purifying respirators would lower personal exposure by a factor of 10× to 50× (CFR 1910.134). Therefore, as shown in Table 7, risk estimates calculated for the same maintenance tasks, assuming use of a half-face air-purifying respirator and a conservative 10-fold reduction in asbestos air concentration, range from 8.3×10^{-8} to 1.4×10^{-6} for the typical scenario and from 7.0×10^{-7} to 9.8×10^{-6} for the high-end scenario.

The aggregate risk can be estimated by assuming that a worker performs each of the various maintenance activities. For the typical scenario, the aggregate duration of exposure is 60 hours per year of ACM-contact maintenance activities. The assumption of 60 hours per year of ACM-related exposure in the typical exposure scenario is the high-end value for the workers in the Corn et al. study and just below the upper 75th percentile of the Price et al. study. The aggregate risk of all maintenance activities is 2.4×10^{-5} for a typical exposed maintenance worker without respirator usage, and 2.4×10^{-6} assuming a 10-fold reduction in asbestos exposure associated with respirator usage. Given the conservative assumptions made in the estimates and the low risk estimates (within EPA's risk range), these risks are not of significant concern.

The aggregate risk can also be estimated by adding together the risks associated with each of the high-end scenarios, resulting in a very conservative, upper-bound risk estimate. However, the total exposure duration for this aggregate risk would exceed the maximum duration found in any of the studies, except for the upper end (90th percentile) from the Price et al. study. The total exposure duration estimated by adding together the high-end scenarios results in an assumption that workers spend 16% of their 25-year occupational career working in contact with ACM, which is similar to the high end of Price's exposure duration measurements. Making this assumption results in an aggregate risk estimate for the high-end scenario of 2.3×10^{-4}, which is

marginally higher than the upper end of EPA's risk range (10^{-4}). If these workers wore respirators, the risk estimate is 2.3×10^{-5}. Therefore, while the vast majority of scenarios result in risks below or within EPA's acceptable risk range, a hypothetical very highly exposed individual who spends 16% of his/her time (about one day a week, every working week of the year, or about 4 years of the 25-year tenure) performing all of the activities considered in this assessment in contact with ACM and does not wear a respirator would be exposed to a risk marginally above EPA's acceptable risk range. Only these most extreme hypothetical aggregate exposure assumptions result in a risk marginally higher than the upper end of EPA's presumptively acceptable risk range. The risk estimate is still below the risk level associated with the governing OSHA PEL (3.4×10^{-3}) by more than a factor of 10.

For a commercial occupant, the plausible upper-bound risk for asbestos fibers is 3.5×10^{-7} for the typical scenario and 1.6×10^{-6} for the high-end scenario. These risks are at or below 10^{-6} (or one in a million) and well within EPA's acceptable risk range of 10^{-4} to 10^{-6}. Given the conservative assumptions made in the estimates, these risks are not a significant concern.

3.6.3 When confronted with uncertainties in the assessment of risks, assumptions were made that tend toward overestimating the actual risks. Therefore, the true risks are likely lower than estimated in this report.

The overall approach of the risk assessment was to develop accurate estimates of typical and upper-end risk, but to make conservative assumptions (i.e., tending to overestimate risk) when confronted by uncertainties. It is a standard practice in risk assessment, employed in this report, to select assumptions that tend to overestimate risk when confronted with uncertainties. These conservative assumptions must be accounted for when interpreting the results.

The key uncertainties in this analysis include:

- The EPA cancer risk factor for asbestos was developed from human epidemiologic studies of people who were exposed to high levels of asbestos

over prolonged periods. The conservatism of EPA's potency factor is consistent with EPA's approach of developing conservative, health-protective risk factors for use in regulatory settings where the mandate is to be public health protective. However, it is likely that the risk is lower, or even zero, at the much lower exposure levels that are associated with a commercial occupant and maintenance worker scenario. Therefore, the use of the EPA cancer risk factor adds significantly to the conservatism of the assessment.

- For both occupants and maintenance workers, typical and upper-bound exposure durations were developed based on available records of worker activities. The upper-bound durations are designed to represent the individuals or workers who may spend the most time in areas with potential asbestos exposure, although the upper-bound durations do not necessarily represent the most highly exposed worker in the U.S., but represent a worker with exposures significantly greater than the average worker.

- The maintenance activity building exposure data were based on PCM measurements, which include both asbestos and non-asbestos fibers. Therefore, the PCM counts likely overestimate the asbestos exposure.

- The risk estimates developed in this report include all ACM contact over the course of a career, not just contact associated with Grace's products. Therefore, the risk estimates for Grace products would be lower, possibly substantially lower. Dr. Richard Lee has noted that Grace products are cementitious and that these products do not spontaneously release fibers (like other ACM products) and are generally resistant to disturbance activities (Lee 2007).

The last two bullets apply to both the comparisons with the OSHA PEL and the EPA risk assessment methodology calculations.

3.7 As part of the risk assessment, I reviewed the weight of the evidence of the epidemiologic data and find that they are broadly consistent with a lack of asbestos-related disease in building maintenance personnel.

Several studies of radiological abnormalities among custodial and maintenance workers have been published (Anderson et al. 1991; Levin and Selikoff 1991; Oliver et al. 1991; Anderson et al. 1992; Matrat et al. 2004). Only the study by Matrat et al. can be considered an epidemiologic study, because it is the only study that included a control group and appropriately considered confounding factors associated with radiological abnormalities, such as age, cigarette smoking, and body mass index (BMI). The most consistent finding of the Matrat paper is an association between BMI and both small opacities (profusion $\geq$ 1/0) and pleural thickening. With regard to markers of asbestos exposure, the study yielded inconsistent results.

Taken together, these epidemiologic studies do not constitute a weight of evidence for a causal association between asbestos exposure associated with ACM in buildings and disease outcome.

3.8 The results of this assessment are consistent with the conclusions of EPA and other regulatory bodies.

The EPA outlined its views on the risks to building occupants and maintenance personnel from in-place ACM in its document, "A building owner's guide to operations and maintenance programs for asbestos-containing materials" (U.S. EPA 1990). This document is frequently referred to as the "Green Book." In the Green Book, EPA states that occupants "appear to face only a very slight risk, if any, of developing an asbestos-related disease." EPA also recommends that asbestos removal occur only to "prevent significant public exposures to airborne asbestos fibers during building demolition or renovation activities." For in-place ACM, EPA recommends an operations and maintenance program to minimize exposures.

A Royal Commission in Canada also came to the same conclusion about building occupants (Dupré et al. 1984). It stated:

> "The risk that an individual who has been exposed to asbestos in a building for, say, 10 years would die of an asbestos-related disease is less than 1/50 the risk that death would come from commuting 10 miles by auto to and from that building daily for the same period. At this level, we deem the risk which asbestos poses to building occupants to be insignificant and therefore find that asbestos in building air will almost never pose a health hazard to building occupants."

Additionally, the British Lung Association states that:

> "Asbestos is still present in a wide variety of buildings, including hospitals, schools and homes, often in walls and ceilings as well as in lagging around steam pipes and boilers. Discovery of asbestos in a building often causes alarm among people living and working in it but usually this alarm is not justified. Providing the asbestos is well maintained and preferably covered by an impermeable layer of paint or other material so that it is not realizing dust, it does not present any hazard to health. It is only the inhalation of loose asbestos fibres which causes disease."[8]

Therefore, the conclusions reached in my report are consistent with the conclusions of other reputable bodies.

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8 See http://www.lunguk.org/asbestos.asp?lung=3.

3.9 The asbestos risks associated with exposure to ACM can be characterized relative to appropriate regulatory criteria.

3.9.1 Compared to relevant regulatory criteria, the theoretical asbestos risks associated with occupant and maintenance worker contact with ACM in buildings are low and not of significant concern.

The estimated risks for occupants were very low, at or below 10^{-6}, and well within or below EPA's recommended risk range.

For maintenance workers, while the risks were higher than those for occupants because the assumed exposure frequency and durations were higher, the lifetime risks for every maintenance scenario are well below the risk associated with the OSHA PEL, which is the operative standard OSHA finds acceptable for worker exposures. Also, when making reasonable upper bound assumptions, the estimated risks were within ranges considered acceptable by EPA. The one exception was the hypothetical upper-bound aggregate exposure scenario, wherein it was assumed a worker spends 324 hours per year, or 16% of their work time, in contact with ACM over 25 years and does not use a respirator. In this case, the estimated hypothetical risk was only marginally above the EPA risk range, but still below the risk level associated with the OSHA PEL.

3.9.2 Compared to other risks to which people are routinely exposed, the risks associated with occupant and maintenance worker contact with ACM in buildings are low.

When characterizing risk estimates, it must be understood that risk is a fact of everyday life. As an example, Figure 2 displays the lifetime risks of dying from a variety of causes. The size of the circles in the figure is roughly proportional to the magnitude of the risks. The risks are highest for heart disease and cancer (all causes) at 18% and 14%, respectively. The upper and lower ends of EPA's acceptable risk range are shown at the right end of the figure. The upper end is at 10^{-4} (or 0.01%) risk, and the lower end is at 10^{-6} (or 0.0001%) risk. The risk of dying

by being struck by lighting is an example of a risk within EPA's acceptable risk range, at 0.002%. However, the risks of dying from a bicycle accident, a fire, drowning, food poisoning, homicide, and others are greater than EPA's upper risk value of 0.01%. These examples show that people live with and accept greater risks than are considered acceptable for environmental exposures by regulatory authorities such as EPA. In fact, these risks are fact-based risks based on actual incidence data, as opposed to the theoretical upper-bound risks presented in this report.

In addition to the risks displayed in Figure 2, it is also worth noting that many environmental risks are similar to or higher than the risks estimated for ACM. For example, Figure 2 shows the average cancer risks associated with air pollutants in urban and rural counties, estimated from EPA's National Air Toxics Assessment. The risks range from 10^{-4} to 10^{-5}, and are experienced by most Americans simply by walking outside or breathing air inside their homes that has infiltrated inside from the outdoors. This is in contrast to the air pollution risk that may exist for residences near an industrial facility, which can be even higher.

Another environmental example is the risks associated with carcinogens in drinking water. Table 8 displays the risk estimates at the maximum contaminant level (MCL) for five chemicals. The MCL is set by EPA as an acceptable risk level for drinking water. The risks are generally in the 10^{-4} to 10^{-6} range, consistent with EPA's acceptable risk range.

These examples show that the estimated risks associated with ACM are similar to or less than risks associated with common activities in everyday life, and are similar to or less than risks of breathing ambient air or drinking tap water.

3.10 Conclusions

The following conclusions were reached through the analysis presented in this report:

1. Health risk assessment is the scientifically appropriate and accepted methodology for assessing the potential cancer risk associated with ACM.

2. The available exposure data for building maintenance workers from ACM disturbance activities were reviewed. The vast majority of exposures were in compliance with the current OSHA PEL, the operative occupational regulatory standard for workers. Also, a risk assessment was conducted according to accepted EPA methodologies. These calculations show that the lifetime risks for maintenance workers are well below the risk level associated with the OSHA PEL, the standard set by OSHA to protect worker health. The estimated exposures are below the level where elevated risks are observed in the epidemiologic studies that underlie the regulatory risk models (i.e., in the zone of inference of the dose-response curve). The risks are also predominantly below levels that are routinely accepted by EPA or experienced in daily activities, and are not of significant concern.

3. The available exposure data for prevalent concentrations in buildings with ACM were reviewed and used to represent exposures to building occupants (e.g., office workers). Generally, the prevalent asbestos concentrations in buildings with ACM are so low that they cannot be differentiated from ambient background levels. Using the exposure data for buildings as an upper bound of the asbestos concentrations from ACM, the estimated risk to occupants is very low, even at the upper bound; the actual risk could be considerably lower than the estimate, and may even approach zero, and is below the observed range of any effects. For these reasons, these risks are not of significant concern.

4. The claimants have not conducted a risk assessment. The data they have presented do not describe exposure and they have made no attempt to use it to estimate exposure and risk. Therefore, they have failed to provide any scientific basis to demonstrate the plausibility of adverse health effects being associated with exposure to in-place ACM.

Table 8. Summary of drinking-water cancer risks at the maximum contaminant level set by EPA

Chemical	MCL (mg/L)	Cancer Slope Factor	Drinking Water Unit Risk	Risk @ MCL[a]
Arsenic	0.010 (mg/L)	1.5 per (mg/kg)/day	5×10^{-5} per (µg/L)	4.30E-04
Benzene	0.005 (mg/L)	1.5×10^{-2} to 5.5×10^{-2} per (mg/kg)/day	4.4×10^{-7} to 1.6×10^{-6} per (µg /L)	2.14E-06 to 7.85E-06
Carbon tetrachloride	0.005 (mg/L)	1.3×10^{-1} per (mg/kg)/day	3.7×10^{-6} per (µg/L)	1.85E-05
1,2-Dichloroethane	0.005 (mg/L)	9.1×10^{-2} per (mg/kg)/day	2.6×10^{-6} per (µg/L)	1.30E-05
Vinyl chloride	0.002 (mg/L)			
Continuous lifetime exposure adulthood				
	LMS Method:	7.2×10^{-1} per (mg/kg)/day	2.1×10^{-5} per (µg/L)	4.11E-05
	LED 10/Linear:	7.5×10^{-1} per (mg/kg)/day	2.1×10^{-5} per (µg/L)	4.28E-05
Continuous lifetime exposure birth				
	LMS Method:	1.4 per (mg/kg)/day	4.2×10^{-5} per (µg/L)	8.00E-05
	LED 10/Linear:	1.5 per (mg/kg)/day	4.2×10^{-5} per (µg/L)	8.57E-05

[a] Intake 2 L/day, 70-kg body weight, lifetime exposure

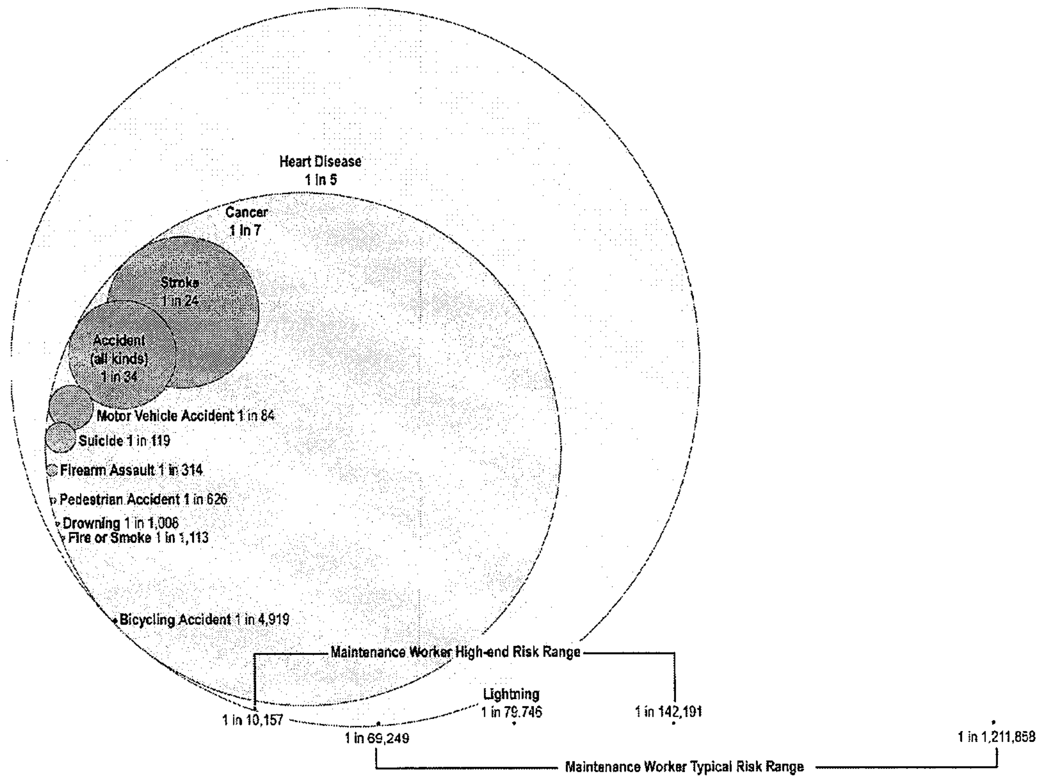

Figure 2. Summary of estimated lifetime mortality risks for various causes. The values are taken from the National Safety Council's website: http://www.nsc.org/lrs/statinfo/odds.htm

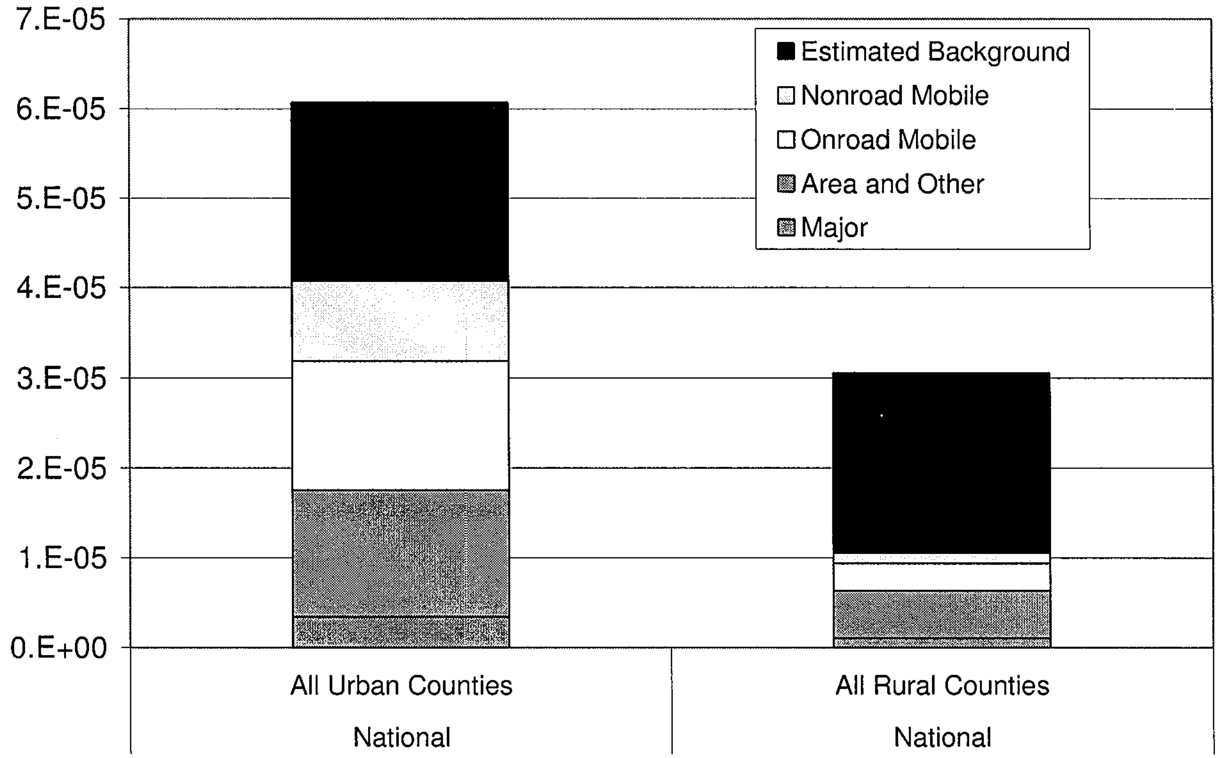

Figure 3. Summary of estimated cancer risks from air pollutants, from EPA's national air toxics assessment

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